# How does Micro Technology Affect Me?

**Lesson Objectives:** Students will be able to do the following:

- Identify one industry that uses microtechnology
- Describe two inventions that affect everyday life
- Compare and contrast micromachines with their larger counterparts

**Warning! Warning!**
**This information is becoming obsolete as it is being written. By the time you receive this packet, the future may be the past. Nanotechnology is growing so fast that is difficult to keep up with the new machines being invented on an hourly basis. There are several interesting sites on the web that have fantastic photographs of some of these inventions. Sandia Laboratories web page and the University of Wisconsin MEMS page are two that I would recommend. The reference list also will lead you to pages from Scientific American and Popular Mechanics that give complete articles on the following material.**

Where might we find these machines tomorrow? Look no farther than the grocery store, manufacturing plants, automobiles, or even your blood stream. Let's take a closer look at some of the machines that nanotechnology has allowed us to produce.

## Micromachines Helping Consumers

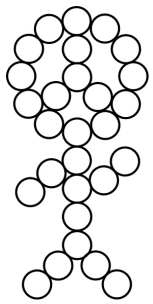
Microsensors have been developed that can test the chemistry of seawater but consider even smaller machines that can be used in other liquids such as your morning juice. As your juice is being scanned at the check out, a **microscopic** "electronic tongue" detects a change in the surface tension or "stickiness" of the liquid. The minielectronic soldier gets to work to further investigate. The microscopic **sensor** measures the chemical properties of the liquid. The information is then sent up a tiny antenna. The information is passed along to the computer database via radio waves. Alert! Alert! The chemical properties are measuring outside normal ranges. The juice is spoiled. The customer receives a fresh container of juice and crisis is averted. No sick customers. No lawsuits. These tiny sensors were first developed by a husband and wife engineering team, Vijay and Vasundara Varadan, at Pennsylvania State University in 1998. The sensors can float freely in products, because they are so small. They are also totally wireless, sending and receiving information using radio waves or microwaves.

# Micromachines Helping Researchers

Scientists are experimenting with miniexplosions in the hopes of creating enough force to start a reaction that could complete a task on a much bigger object. The miniexplosives or rocket propellants are stored in cavities of the **integrated circuits** of a **microchip**, because they provide convenient containers. By igniting one or more explosive at a time, scientists can control the intensity of the **thrust** produced. Since the microchips containing the explosions take up little room, many microchips can be equipped with materials to cause explosions over long periods of time, even over years. In this way, drugs could be pulsed through a system or a satellite could be reoriented in space.

The demand for smaller and smaller technical devices has led researchers to try to continue to shrink the size of electronic equipment that people use everyday. For instance, Peter Gammell and his colleagues at Bell Labs/Lucent Technologies have further reduced the size of three components of a cell phone. They have predicted, with their advances in **nanotechnology**, a cell phone that would fit on one silicon chip is possible by the year 2005. This is important because it paves the way for miniaturization in other fields, including the construction of key components in the expanding voice activated technologies industries.

Miniature microphones are also in the news. Engineers in Denmark and Germany have created silicon chips about two millimeters square which contain many condenser microphones that sense the waves created as sound is converted to an electrical signal. These are unique, because they work as well as conventional microphones ten times their size. Other European scientists have created what they call a "microflown". This instrument has no moving parts but actually senses the "wind" that accompanies a moving wave. What does all this mean? Highly sensitive sensors can be made cost effectively to help in a wide variety of jobs such as detecting underwater mines in murky water or helping someone to hear with a truly invisible hearing aid.



## Micromachines Helping Doctors

Micromachine assistants may soon allow doctors to be everywhere. Scientists envision micromachines made from one molecule that could "swim" through the blood stream detecting and destroying harmful viruses. This dream comes closer to reality every day as researchers refine their nanotechnology fabrication techniques. An assistant professor of agriculture and biological engineering at Cornell University, Carlo Montemagno, has created a tiny motor made from a single molecule of **ATPase** bonded to a nickel foundation. In the cell, ATPase changes food into usable energy. During this process, the central **protein** part of the ATPase rotates just as the propeller on a motor does. With genetic manipulation, scientists were able to control the movement of this propeller and actually start and stop its rotation. This research has laid the foundation for nanofabrication of **hybrid** systems made from both living and nonliving materials. The machines made from these techniques could be used to pump fluids through the body.

As doctors today use lasers to enter the body in less invasive procedures, imagine instruments designed to enter human cells. These laser tweezers and scissors cut and hold cell parts trapped in beams of light. Laser scissors have been around for about thirty years. These beams of light are called scissors, because they can make permanent changes in cells even though scientists do not know the exact mechanism. Scientists can reproduce the results without injuring the other cell parts. In the past few years, laser tweezers first developed in the 1980's, have been refined to the point that they can actually grasp individual molecules. The use of laser scissors and tweezers together allows scientists to manipulate small elements of the cell that are part of the cell's reproductive process. By working with the components important in cell division, scientists could unlock the mysteries of cancer and birth defects.

## Micromachines Helping the World

As microtechnology becomes nanotechnology the possibilities are endless. Imagine all the jobs that microscopic machines could do such as cleaning up pollution or working with hazardous waste materials. We may be able to create synthetic food sources, so people would not be hungry. If someone were injured, we may be able to piece tiny blood vessels back together with microvelcro. The future is now!

# Activity: Micromachines Vocabulary Builder

| | | |
|---|---|---|
| Mechanical | Electronic | MEMS |
| Nanotechnology | Micro | Atoms |
| Semiconductors | Miniature | Nano |
| Scanning Tunneling Microscopes | | |

**Fill in the blank with the correct word.**

1. _____devices have moving parts.

2. _____are the smallest building blocks of any substance.

3. _____means one millionth.

4. _____are micromachines with electrical and mechanical parts.

5. _____are instruments that help scientists to move and position individual molecules.

6. _____are the base components of microchips.

7. _____items are smaller in size than the originals.

8. _____devices control the movement of electrons through a gas, vacuum, or semiconductor.

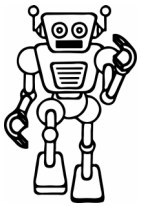
9. _____is a term that is used to describe the smallest microscopic things.

10. _____is used to build electronic circuits and devices from molecules and atoms.

# Vocabulary Builder Answer Key

1. Mechanical
2. Atoms
3. Micro
4. MEMS
5. Scanning Tunneling Microscopes
6. Semiconductors
7. Miniature
8. Electronic
9. Nano
10. Nanotechnology

# Activity: Future Micromachines' Commercial



Throughout history inventions were created that have made our lives easier. Some of the things we use today were unheard of years ago. The new frontier in science today includes the microenvironment where today's discoveries are leading to new inventions for the future.

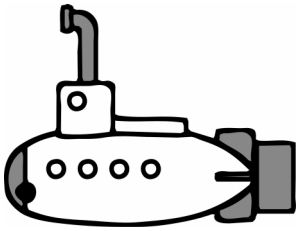
**Objectives:** Students will be able to do the following:
1. Design a futuristic micromachine
2. Create a presentation to sell their micromachine.
3. Explain their micromachine to an audience.

**Materials:**
- Research materials such as magazines, newspapers, or Internet
- Paper and pencil
- Art supplies to create a brochure (This could also be done on a computer.)
- Props created by the students

**Procedure:**
1. Discuss with students current world problems that may be solved with the invention of micromachines.
2. Have students research some of the current literature on new micromachine inventions and technology.
3. Have students work in pairs to design a micromachine.
4. Have student pairs develop a brochure for prospective customers of their machine.
5. Have students give a presentation that would advertise their machine. (This could be a live presentation or video taped ahead of time.)
6. Be sure students include the following information in their written materials and oral presentations:
   The name of the invention
   The purpose of the invention
   Whom the invention would benefit
   The materials required to construct the invention
   The people involved in the construction of the invention
   Why people should buy this particular machine

**Possible Extension:**
1. Have students build a model of their invention.
2. Have students design a machine that fits into a particular category such as the health field.
3. Have students design a machine that solves a particular problem such as world hunger.

## Student Information: Microsystems in Review



When inventions are first created they are usually crude. They are large and sometimes don't work very well. As more discoveries are made, products usually shrink in size and work better. This is true of the **electronic** inventions that we have today. The first computers were very large taking up whole rooms. They overheated and broke down often. With the development of new small parts, computers also became smaller. We could describe our personal computers today as miniatures of those first computers. Miniature simply means a smaller model.

As things became even smaller in size, scientists were able to create **micromachines**. These machines had **microscopic** parts. In the distant past microscopic simply meant small. Then it came to mean those things that could only be seen with the aid of a **microscope**. In exact measurement, **micro** means one millionth. A micron or micrometer is one-millionth the size of a meter. A human hair is about 100 microns in diameter. The micromachines made by scientists are much smaller than this, but they can still do such things as trigger the release of airbags in cars or redirect satellites in space

Now scientists have built even smaller machines whose parts are made from individual **atoms** or **molecules**. Scientists use the term **nano** to describe them. Nano actually means one billionth, so it describes something 1000 times smaller than a micron. How small is that? More than five million nanomachines could fit into the print on this page.

As new discoveries are made, more jobs become available for people with a wide variety of talents. Perhaps you could be one of the scientists of tomorrow creating robots that would rid the world of disease.

# Microsystems Vocabulary

**Actuator**-an instrument used to activate a mechanical device

**Amplification**-to increase the magnitude of something such as microphones amplifying sound

**Animated**-designed or constructed to move as if alive

**Atom-**the smallest particle of an element having the characteristics of that element

**ATPase-**a substance that breaks down adenosine triphosphate, an energy carrying molecule found in all living cells

**Carbon monoxide-**a colorless, odorless, poisonous gas with the formula CO

**Cellulose**-main component of the cell wall in most plants

**Celsius-**a temperature scale that registers the freezing point of water at 0° and the boiling point of water at 100° under normal atmospheric pressure

**Conductor**-a substance that allows electrons to flow through it easily

**Crystal**-a solid formed by a repeating three-dimensional pattern of atoms, ions, or molecules that have set distances between the constituent parts

**Current**-the quantity of electricity that flows through a circuit

**Diatom**-microscopic, one celled plant having cell walls made of silica

**Diode**-an electronic component made of two electrodes that can be used to control the flow of a direct current

**Direct current-**electric current that flows in only one direction

**Dopant**-a substance that changes the electrical properties of a semiconductor

**Electricity**-flow of electrons through a circuit used as a power source

**Electrode**-a conductor that allows electric current to enter or leave a device

**Electron-**a negatively charged particle found inside an atom

**Electronics**-the science that deals with the controlled movement of electrons in a gas, vacuum, or semiconductor

**Element**-a substance made up of atoms that have the same number of protons in each nucleus

**Etch-**to make a pattern on the surface of a material with acid

**Fabrication**-construction

**Flagella**-whiplike extensions of unicellular organisms used for locomotion

**Friction**-a force that slows moving objects as they rub together

**Gravity**-the force of attraction between any two massive bodies

**Hybrid**-something made of mixed composition

**Insulator**-material that will not allow electrons to flow through it

**Integrated circuit**-a tiny chip on which electronic components and their connections are etched

**Mainspring**-the principal spring in a watch or clock that drives the mechanism by uncoiling

**Mechanical**-having moving parts

**Mechanization**-machine operated production

**Micro**-small scale; one millionth

**Microchip-**integrated circuit, silicon chip

**Micromachine**-machines with microscopic parts

**Microelectromechanical systems (MEMS)**-microscopic devices that have a mechanical and electronic component, micromachine

**Microscope**-an instrument that used to magnify small items

**Microscopic**-too small to be seen with the unaided eye, but large enough to be studied under a microscope

**Molecule**-the smallest particle of a substance that retains the chemical and physical properties of that substance

**Nano**-extremely small; one billionth

**Nanotechnology**-the science and technology of building electronic circuits and devices from single atoms and molecules

**Neutron**-a particle with no electric charge found in the nucleus of an atom

**Nucleus**-the central region of an atom

**Polymer**-compound of high molecular weight made of repeatedly linked units of simple molecules

**Proton**-positively charged particle in the nucleus of an atom

**Protein**-complex organic compounds made of amino acids

**Scanning tunneling microscope**-a microscope that scans the surface of a sample with a beam of electrons producing a three dimensional image of atomic topography and structure

**Semiconductor**-a substance whose ability to conduct electricity increases at higher temperatures and with the addition of substances called dopants

**Sensor**-a device that receives, measures, and records a signal

**Silicon**-a nonmetallic element that consists of dark gray crystals

**Silicon dioxide**-a compound composed of one silicon atom and two oxygen atoms that occurs naturally as sand

**Template**-a pattern used as a guide to make something accurately

**Thrust**-driving force or pressure

**Transmission**-a signal sent from one place to another

**Transistor-**a semiconductor device with at least three terminals; The amount of electricity passing between the first two electrodes can be controlled by the voltage on the third electrode making it useful as a switching device.

**Triode**-a device consisting of 3 metal electrodes inside a glass vacuum tube used to control a flow of electricity

**Ultraviolet light**-a range of invisible electromagnetic radiation having wavelengths shorter than the violet in the visible spectrum

**Vacuum tube**-an electron tube from which most of the gas has been removed permitting the electrons to move with low interference from other molecules

**Voltage-**electromotive force or potential difference

**Work-**a force moving an object through a distance

**Xenon**-colorless, odorless, inert gaseous element found in minute quantities in the atmosphere used in laser-pumping lamps

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